DOCUMENT RESUME

ED 187 293 HE 012 784

TITLE	Review Processes: Assessing the Quality of Research Proposals.
INSTITUTION	National Commission on Research, Washington, D.C.
PUB DATE	May 80
NOTE	31p.
AVAILABLE FROM	National Commission on Research, Suite 1003, 2600 Virginia Avenue, NW, Washington, DC 20037 (free)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Accountability; Colleges; *Evaluation Criteria; *Federal Aid; Federal Government; Financial Support; *Government School Relationship; Higher Education; Peer Evaluation; Program Evaluation; *Quality Control; Research Projects; *Research Proposals; *Universities
IDENTIFIERS	Research Universities

ABSTRACT

Issues concerning review processes used to select research to be performed in universities and supported by the federal government are discussed. Recommendations regarding review processes, with special emphasis on the peer review system, are offered. It is proposed that review processes serve government and researchers' purposes of assuring that taxpayer dollars have been invested in high quality research and that the judgments made leading to the investment in research have been equitable and discerning. Systems of review used by the following large funding agencies are briefly described: National Institutes of Health, National Science Foundation, Department of Defense, Department of Energy, Department of Agriculture, and the National Aeronautics and Space Administration. Some of the problems caused by the need for review processes are examined, as are criticisms of peer review in particular. (SW)

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REVIEW PROCESSES:

Assessing the Quality of Research Proposals

ED 187293

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NATIONAL COMMISSION ON RESEARCH
Review Processes: Assessing the Quality of Research Proposals

Executive Summary

For the better part of a half century, the Federal government and the research universities of the nation have been associated closely in the support and performance of research. Recently, this relationship has become strained. The partners have developed different views on the objectives of their association and the conditions of their collaboration.

The Commission

The National Commission on Research was formed in late 1978 as an independent body. It was sponsored by interested organizations and supported principally by private foundations. The Commission was charged to study the relationship between the government and the research universities, to determine the nature and origins of the problems afflicting the relationship, and to recommend ways to solve these problems. Additional information on the origins and purposes of the Commission is contained in the Foreword (p. vii).

Review Processes

Review processes are the methods used to select research to be performed in universities and supported by the Federal government. In this document, the Commission presents its views on the issues, its conclusions, and its recommendations regarding review processes, with special emphasis on the peer review system.

The Introduction (p. 1) asserts that review processes serve government and researchers' purposes of assuring that taxpayer dollars have been invested in high quality research and that the judgments made leading to the investment in research have been equitable and discerning. Systems of review used by several large funding agencies are described briefly in the next section (p. 3). The Issues section (p. 7) states some of the problems caused by the very need for review processes and examines the criticisms of peer review in particular.

Conclusions

The Commission derived several conclusions from its study (p. 13):

1. Scientists, universities, and the government all want a system of review and award which ensures equal opportunity to all investigators, minimizes error, assures fairness, selects the best research, and can be managed with reasonable costs of time and money. A system of review, however, which is totally free of error, differences of judgment, or personal preferences probably cannot be designed.
2. The Commission concludes that the plurality and diversity of review processes available are appropriate, provided that equality of opportunity is assured and that the quality of proposals selected is high.
3. The Commission recognizes the criticisms of peer review and agrees that the peer review system is not immune to faults. Still, the system has worked well, and most agencies have been attentive to developing and testing appropriate safeguards to ensure its integrity and effectiveness.
4. The Commission believes that deciding the direction of U.S. science through the open competition of unsolicited proposals, and especially through the selection of proposals through peer review, is of great importance to the success of U.S. science and, therefore, deserves support.

TEAR SHEET—EXECUTIVE SUMMARY REPEATED ON PAGE ix

Recommendations

An explanation of each recommendation is contained in the full report (p. 15). The Review Processes recommendations of the National Commission on Research are:

1. The Commission recommends that the review systems used in the different funding agencies be examined periodically, both by internal and external groups, to ensure that they are working effectively and equitably.
2. The Commission recommends experimentation within the funding agencies to refine the review processes and recommends that legislative or administrative restrictions which limit such experimentation be modified.
3. The Commission recommends that funding agencies initiate retrospective studies on how effective their review processes have been in assessing the quality and impact of the research they support.
4. The Commission recommends experimentation by federal agencies in which peer reviewers provide ratings for several aspects of a proposal as well as the overall rating. This would assist program officers in knowing what qualities and in what measure a peer reviewer has assessed the overall proposal and would assist program officers in making the funding decision.
5. The Commission recommends that funding agencies make explicit the nature of the underlying scientific and policy considerations used in arriving at funding decisions.

REVIEW PROCESSES:

Assessing the Quality of Research Proposals

National Commission on Research
May 1980

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Foreword

The National Commission on Research is a private, nonprofit organization established to examine the relationships between government agencies and universities involved in research and to develop specific recommendations for improvements. The Commission was founded in the latter half of 1978 by the American Council on Education, the American Council of Learned Societies, the Association of American Universities, the National Academy of Sciences, the National Association of State Universities and Land-Grant Colleges, and the Social Science Research Council. The Commission works independently of its founders to examine the process by which the Federal government supports academic research and to propose changes designed to improve that process.

Funding has been obtained for Commission activities to pursue this task from the following organizations: Carnegie Corporation of New York, Exxon Education Foundation, Ford Foundation, the William and Flora Hewlett Foundation, the Andrew W. Mellon Foundation, the National Science Foundation (Grants Nos. PRM-7903778 and CDP-7926386), the U.S. Department of Energy (Grant No. DE-FG01-80ER10167) and the Air Force Office of Scientific Research (Grant No. AFOSR-ISSA-80-00030). Over three-fourths of the funding was made available by the five private agencies and approximately one-fourth from the public sources. Any opinions, findings, conclusions, and recommendations expressed in this publication are the sole responsibility of the Commission and do not necessarily reflect the views of any of the aforementioned funding sources or founders.

This publication on review processes is the third in a series of documents to be developed by the Commission to analyze the process of government funding and university involvement in research and to make recommendations to all affected parties for improvements in the system. Subcommittees of the Commission were established to investigate each of the following issues:

(1) Accountability;
(2) Peer review and other selection processes;
(3) Alternative funding mechanisms;
(4) Industry/university/government relationships; and
(5) Development of research personnel.

Position papers on each topic will be published by the Commission.

The members of the Subcommittee on Review Processes are Philip P. Cohen, Chairman; Irwin C. Lieb; and William H. Sewell.

In addition to surveying the available literature, subcommittee members and staff meet with selected officials from business, government, and the universities. At monthly meetings, invited speakers present their views on pertinent aspects of the listed topics or on the broad purview of the Commission. The Commission has received testimony on five university campuses from faculty members and administrators, as well as written comments stemming from invitations to research universities and from an open letter in *Science* magazine. Liaison with numerous government agencies is maintained through telephone contacts, correspondence, and attendance at Commission meetings. Approximately one hundred fifty persons have given advice and information to assist the Commission in its study thus far. The Commission appreciates the efforts of all the participants in its deliberations and discussions. A description of these considerations and a partial list of individuals are contained in the Appendix.

The members of the Commission are listed inside the front cover. These individuals have backgrounds in education, business, and government. They have accepted appointments to serve on the Commission without compensation. During Commission deliberations, they reflect their own experience and not necessarily the viewpoints of their institutions or organizations.

Liaison persons have been designated to the Commission by the following government agencies: Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA); Department of Defense (DOD); Department of Energy (DOE); Department of Health, Education, and Welfare (DHEW); General Accounting Office (GAO); National Aeronautics and Space Administration (NASA); National Institutes of Health (NIH); National Science Foundation (NSF); Office of Management and Budget (OMB); and Office of Science and Technology Policy (OSTP).

In its series of publications, the Commission will review the key elements of the present state of federally supported university research, affirm what it believes to be good in this system, analyze problem areas, and

provide suggestions for actions to alleviate these problems. The Commission recognizes that much diversity exists in the complex relationships among principal investigators, research administrators, and others in the university community, and program officers, auditors, administrators, and other government personnel. There is a wide range of beneficiaries, including industry, students, and the general public. The goals of the participating government organizations and educational institutions and of the concerned individuals involved in federally supported research are diverse and sometimes overlapping but not identical. Therefore, the Commission does not anticipate the ability to establish consensus on all of the issues. The Commission does seek to make a contribution to improved research in our nation by improving a system which produces a major portion of that research.

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An explanation of each recommendation is contained in the full report (p. 15). The Review Processes recommendations of the National Commission on Research are:

1. The Commission recommends that the review systems used in the different funding agencies be examined periodically, both by internal and external groups, to ensure that they are working effectively and equitably.
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Introduction

Following World War II, the Federal government began new, major programs to develop the basic and applied sciences and to encourage able young people to become scientists. Many programs were expanded in response to the challenge of the Soviet launching of space satellites in the 1950s. University science departments and medical, agricultural, and engineering colleges were the natural homes for much of the research the government wished to support—for research to be conducted by their faculties, for equipment, for laboratories, for faculty development, and for predoctoral and postdoctoral fellowships. Before World War II, basic science research in the United States had tended to be supported by universities themselves, private foundations, and modest government funds. Basic research was not conducted, as it was and is in many other countries, in government institutes and centers largely independent of universities. Most of our basic scientists were professors in universities; their instruction of advanced students was mainly in research. It was of the universities, which already had well established science faculties and facilities, then, that the government thought when it sought to expand existing support of basic research and training. More science could be conducted in the universities; young scientists could be prepared in them—both programs would answer the nation's need.

For three decades, the Federal government has continued major support for basic science in universities. Urgencies which first led to the increased support have passed, but new urgencies have occurred from time to time; there have been changes in emphasis because of national concerns and because of the promise of different fields in the sciences themselves. Support also has been continued because of the wide realization that it is in the national interest to have basic research conducted, and conducted largely in the universities: research leads to improvements in agriculture, in the diagnosis and treatment of disease, in technologies which increase productivity and lead to new products; it contributes to the prestige and security of the nation. The government's continued investment in university science has been very successful, and the prospects for university science still seem to be very strong.

The Federal government had developed its programs so that they were appropriate to the universities and the ways in which the universities conduct research. University researchers are professors; they teach as well as conduct research, and while they may instruct their graduate students as they conduct research, many of them also teach undergraduates and have responsibilities in the broad work of the whole university. Government support thus had to be arranged in programs which recognized the several responsibilities of university scientists—and which also recognized that the basic research of scientists in universities is planned and conducted by them *as individuals*.

There have been—and perhaps there will continue to be—strains in fitting the government's interests and procedures to the universities' concerns and ways of doing things. But one of the most successful instruments for directing support to individual university scientists has been to have ranking scientists assist government agencies in the review of research proposals and to recommend to federal agencies those proposals which are likely to result in the best science and, therefore, are the most worthy of support. The procedures for these recommendations are called "peer review." Their advantage and effectiveness are that in open competition, they lead to the support of the research which scientists themselves think is best—and they give to scientists the assurance that the system which supports their research is fair and discerning and directed toward concerns which they share as scientists.

Because the quality of peer review is of great importance to the government and to university scientists and because it has been criticized by some members of Congress and some members of the academic community, it has seemed to the National Commission on Research that peer review deserves special study. This report presents the Commission's views on the methods used to select research to be performed in universities and supported by the Federal government, with special emphasis on the peer review system. It addresses the difficulties of choosing and funding the best research proposals and nurturing a large and increasing community of scientists, while ensuring equity among investigators. Peer review is recognized by Congress, the agencies, and university scientists to be one source of scientific accountability for the public funds awarded to researchers. However, the widespread acceptance of peer review as a way of funding science fairly and effectively and as a means of providing scientific accountability has not gone unquestioned. The government, for example, is concerned with whether the taxpayers are getting value for their dollars and whether there is any evidence of favoritism in the reviews conducted by its funding agencies. These points also have been raised within the university community.

This report begins with a description of the systems of review used in agencies whose funds make up almost 90 percent of the federal research dollars expended in universities. It continues with a discussion of the criticisms of peer review that have been publicized and examined. Next, the report presents the conclusions reached by the

National Commission on Research. Finally, there are recommendations for improvements in the proposal review processes.

Since most of the work sponsored currently by the federal agencies at universities is in fields of science, this report often specifies "science" and "scientists" instead of "research" and "investigators."

Systems of Review

Some federal agencies use internal review exclusively; some use a combination of internal and external reviews; and some use an external review process exclusively. Program officers in the agencies award funds on the basis of the outcome of the review process: the quality and promise of the research and its priority among the proposals reviewed as acceptable. In making funding decisions, program officers and other agency officials include their own evaluation and assessment of the proposal's relevance to the agency mission, its balance, and other factors.

Internal Review

Agencies employ full-time, trained scientists on their staffs to administer their research program spending. In those instances in which these scientists are responsible for the technical review of research proposals, the agency is said to have internal proposal review. Criteria for excellence are generally the same as in agencies with external review. However, there is usually a stronger mission orientation in agencies which use internal review. Program officers, as the scientists usually are called, decide which research will receive funds by considering which proposals are the most promising and how well the proposed research fits the agency mission. Proposals selected for funding must be approved also by several levels of research administrators within most agencies.

Internal reviewers have the option of seeking an outside opinion on the quality of a particular proposal. The outside opinions usually are requested from scientists in other programs within the same agency, in other agencies, or in the university community.

External Review

In external review, research proposals are reviewed by scientists who are not employed in a government funding agency. While efforts are made to choose reviewers from different parts of the country and from special segments of the scientific population, the primary criteria are scientific competence and accomplishment. Ideally, an external review group represents the judgment of the finest scientists in the nation; their recommendations are to assure that the federal funds are used to support the best scientists and the most promising research.

The words "peer review" have a widely accepted special meaning: review by scientists who are actively engaged in research, who are not employed by a funding agency, and who have the research experience and achievement which will permit them to make discerning judgments on the scientific merits of proposals. In this context, *external review* is in essence *peer review.*

While the reviews which are conducted in some agencies by competent staff scientists can be considered to be a review by peers, the university community is sometimes wary of these reviews. Researchers, in the universities and elsewhere, prefer to think that their peers are those who are engaged in research currently—for they are aware of the rapid rate at which science moves and changes direction and of how quickly those who do not engage in research can be left behind and even fail to be informed about the promise in new developments.

External review may operate in either of the following ways, or in a combination of both:

1. Peer reviewers, selected by agency staff members, are sent a proposal for evaluation. The accompanying letter and form provided for the reviewer describe what is expected from the external reviewer. Table I (p. 6) refers to this method as "mail review."

2. Peer reviewers are selected to serve for a fixed term and meet as a group several times a year with agency staff members to evaluate proposals that have been circulated well in advance of the meeting. In special cases dealing with a complex or interdisciplinary proposal, an *ad hoc* group may be convened for more limited tenure. Table I refers to this procedure as "panel review."

The evaluations which result from the external review systems are used in different ways by the agency program officers in deciding which proposals will be funded. While peer reviewers assess the scientific quality and research feasibility of proposals, they also advise agencies on the appropriateness of the budget request to the research described, but funding decisions are the responsibility of the agency, not of the peer reviewers.

Choice of Review System

Different federal funding agencies use different review processes, or use the same basic review system but alter its procedures in some way. Each agency, of course, chooses a review system which it believes will lead it to support the best proposals, and each believes that it chooses the best research projects by the review system

it employs. What, then, is the basis for the decision to use external (peer) review or another system in different agencies?

There seem to have been no formal criteria for the decisions to use peer review or another system. Internal and external reviews have grown out of the traditions of different agencies and have developed along with the administrative systems in the agencies. In some, where research interests are focused and continuing, internal review usually has been favored. In others, where there are a variety of research interests and a large number of applications, and in those which want their reviews to be closely comparable to the reviews which are conducted in the universities and the scientific community generally, peer, or external, review is the process of choice. Peer review has been legislatively mandated recently for a small, competitive grant program in the Department of Agriculture, and a dual system has been mandated for the National Institutes of Health and the Alcohol, Drug Abuse, and Mental Health Administration.

Review Processes Used by Federal Agencies

National Institutes of Health

The National Institutes of Health (NIH) and the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) use a dual system of peer review. First, proposals are evaluated for scientific quality by panels of experts in the specific field, known as Study Sections or Initial Review Groups. There are currently 54 such panels which meet three times each year at NIH and review approximately 25,000 proposals annually. The Study Sections are managed by a division of NIH which is separate from the program divisions. After open discussion, the members of the Study Section (12-20 scientists) vote individually by means of a numerical rating if a proposal is approved, or by indicating disapproval. The Executive Secretary (an NIH staff member) then determines the overall priority rating from the individual numerical ratings and submits this together with a summary statement to the second level of peer review, the National Advisory Council.

Each Institute of the NIH has its own Advisory Council, which is made up of ten or more scientists and physicians and which includes nonscientist, public representatives as members. Each Council considers the priority scores of the proposals reviewed by the Study Sections with respect to need and relevance to the categorical mission of each Institute. The Advisory Councils must vote for approval (or disapproval) of each of the proposals under consideration at regular meetings sometime after receiving the recommendations of the Study Sections. No funds can be awarded without the approval of an Advisory Council with the exception of the following: (1) current NIH fellowship program; and (2) requests of under $35,000 in the National Cancer Institute and the National Heart, Lung, and Blood Institute. In most cases, the members of the Advisory Councils rely on summary sheets prepared by the Executive Secretary of each Study Section for information regarding each proposal. In addition, the Executive Secretaries of the various Study Sections meet with the Councils to supply other relevant information at the request of the Council members.

National Science Foundation

The National Science Foundation (NSF) reviews about 26,000 research proposals annually for a program budget that is substantially less than that of the NIH. The National Science Foundation uses external reviewers in the following ways: (1) mail review, (2) panel review (comparable to a Study Section in NIH), or (3) a combination of both. Some program managers rely almost exclusively on mail reviews and others almost exclusively on panels that meet and consider all proposals in open discussion. Reviewers are experts in appropriate disciplines chosen by the program directors to advise NSF on the technical and scientific worth of proposals. Funding decisions are made by responsible NSF staff using the evaluations provided by the reviewers.

In 1979, the average number of NSF reviews per proposal was 8.5 overall, ranging from a low average of 5.2 in the Mathematics, Physical Sciences and Engineering Division to a high of 12.7 reviews per proposal in the Biological and Behavioral Sciences Division. The former division did 79 percent of its reviews by mail, and the latter division used the mail and panel combination for 94 percent of its reviews.

Department of Defense

The Defense Advanced Research Projects Agency (DARPA) supports research and development programs that are high-risk and at the forefront of technology. It can be characterized as having minimal administrative

constraints on proposal review. Three other branches of the Department of Defense (DOD) also support basic research in universities. Scientific officers in the Air Force Office of Scientific Research (AFOSR) and the Office of Naval Research (ONR) are responsible for the technical review of proposals. The Army Research Office uses external review exclusively. A few programs within AFOSR (chemistry and mathematics) and ONR (biological sciences) use an external review system regularly, but scientific officers in their other programs may choose external reviewers to assist in the evaluation of certain proposals at their discretion. When employed at DOD, external review is a single system of peer review involving either mail review or panel review.

Management of most external review groups at DOD is accomplished in conjunction with other individuals or organizations. The Chemistry Division of AFOSR contracts with a coordinator each year; the Mathematics Division of AFOSR is affiliated with the National Mathematics Society for purposes of proposal review; and the Army Research Office is advised by a committee of the National Research Council. Once the technical reviews have been submitted, there are several internal layers of priority rating and approval within each of the DOD branches that must be negotiated before a proposal receives funding.

Department of Energy

The Department of Energy (DOE) has review procedures which differ according to whether the research is to be done in their national laboratories or elsewhere. The Office of Basic Energy Sciences and High Energy and Nuclear Physics and the Office of Health and Environmental Research initially screen proposals internally and then have them reviewed externally for technical quality. If a proposal comes from a principal investigator at a university, an attempt is made to assign reviewers from the academic community. A peer review panel system similar to that used in NSF will be used in the new DOE Program for Biological Energy Research for evaluation of proposals.

Department of Agriculture

Most research funds from the Department of Agriculture (USDA) have been allocated to state agricultural experiment stations on the basis of legislatively mandated formulas. Utilization of these funds for support of basic research has varied in the different land-grant universities. Recent legislation (Public Law 95-113) has established an additional, small, competitive grants program to encourage basic science research in universities and makes USDA the lead agency for food and agricultural sciences.

In its programs of direct funding of agricultural research to universities (other than the mandated formula grants), the USDA uses peer review procedures. With the inception of the recent mandate for peer review in one program (see above), the department is attempting to define and develop a system of external review that would apply across programs.

National Aeronautics and Space Administration

All unsolicited proposals from investigators at universities are processed through the Office of University Affairs at the National Aeronautics and Space Administration (NASA). Proposals are evaluated by NASA program offices in Washington, D.C., and/or field installations which the Office of University Affairs determines may have an interest in them. The Office of University Affairs is responsible for notification of acceptances or rejections and for negotiations between NASA's Procurement Office and the universities regarding the funding instruments.

Summary of Systems

Review systems of the foregoing agencies are summarized in Table I on the following page. As was noted earlier, these agencies provide almost 90 percent of the federal funds expended for research in universities.

TABLE I

Review Processes Used by Several Federal Agencies

Agency	Review System	Processes	Choice of Peer Review	FY 1979 Expended Research Funds to Universities
Department of Agriculture	External for basic research proposals. Formula funds to agricultural experiment stations sporadically reviewed internally and externally.	Mail review when external review used.	Usually used, except for new competitive grants for which use is legislatively mandated.	$ 206,000,000
Department of Defense				364,000,000
Air Force Office of Scientific Research	External only for certain programs (chemistry, mathematics). Mostly internal.	Mathematics: mail reviews; chemistry: panel.	Traditionally used at discretion of scientific officer.	
Army Research Office	External and internal followed by internal funding decision.	Mail review.	Committee of National Research Council selects reviewers.	
Office of Naval Research	Internal, except in Biological Sciences Division.	Mail review when external evaluation used.	At discretion of scientific officer on individual proposal basis. Traditionally external for Biological Sciences.	
Department of Energy	External in some programs; internal in others.	Mail and/or panel when external.	Program director's discretion.	292,000,000
National Aeronautics and Space Administration	Internal.	Mail if external review needed.	Reviewing office or field installation through Office of University Affairs.	144,000,000
National Institutes of Health	External, dual system.	Technical review by Study Sections meeting as panel; then panel review by National Advisory Councils.	Legislatively mandated.	1,770,000,000
National Science Foundation	External.	Mail, panel, or combination of mail and panel, depending on program.	Traditionally used.	602,000,000

Issues

Problems of Review Processes

The need for increased support for basic science has received increased attention in the past several years from Congress and particular emphasis by President Carter in his Science and Technology Message to Congress in March 1979. This increased interest in scientific research, combined with a needed assurance that the government is getting value for its research investment, has been accompanied by an increased concern for the quality of scientific review systems.

Congressional oversight committees have scrutinized the peer review system in NSF; the Office of Management and Budget has studied peer review in NIH; the General Accounting Office has examined peer review at NSF; and several internal evaluations of peer review have been conducted at NIH and NSF. The reasons for focusing on these agencies are (1) that they provide most of the funds supporting research in universities; and (2) they both use peer review. Internal review systems in other agencies have not been scrutinized to the same degree, possibly because fewer dollars are involved or perhaps because the research programs of those agencies are a small fraction of their overall missions.

The fundamental issue in supporting research is to choose among proposals those that are deemed most likely to produce research of high quality and to advance basic knowledge leading to application. A practical question in selection is how to be assured that research yet to be conducted will be worthwhile. Here, agencies rely on the experience, knowledge, and insight of reviewers. Well chosen scientific peers are appointed because they know their fields, because they have participated in their development, because they have insight into those aspects where new growth is needed and can be expected to occur, and because they can make critical assessments of the ability of applicants to succeed in new research.

Normally, agencies will establish minimum requirements for the acceptance of research proposals, such as (1) a revealing and feasible research design; (2) assurance that the investigator has the competence, resourcefulness, and persistence to conduct, complete, and report the research; (3) evidence that the investigator has or can get the resources and facilities to conduct the research; and (4) evidence that the research will be of value.

Some items on such a list of minimum requirements are easier to establish than others (and easier to defend against criticism). In some cases, some of them are difficult: measures of risk are not always clear; some proposed research may be "break through or bust," fruitful or isolated. Agencies, especially in response to criticism, may be led to make their selections very conservatively. But if it were a checklist matter to choose among applicants for support, there would be no need to have any sort of scientific review. There are unpredictabilities in the development and application of science. These cannot be resolved finally, though in one area of science or another they can be reduced occasionally, especially as reviewers reflect on the ultimate assessment of quality and merit of research as determined by (1) the acceptance of the research findings by other scientists; (2) the impact and usefulness of the findings in furthering new research in the same or related areas; and (3) the utility of the research findings in application of the basic knowledge for development of practices or technology useful to society. However, these assessments can be made only retrospectively.

Enterprises which involve judgment need to be examined periodically and account taken of valid criticisms. An effective stimulus to improvement is criticism. It is therefore appropriate, considering their scale and importance, that review procedures—particularly peer review—be under the scrutiny of Congress, the funding agencies, the scientific community, and the public.

Criticisms of Peer Review

Critics of peer review have included some members of (1) Congress, (2) the federal agencies, (3) the university community, and (4) the public press. The Office of Management and Budget focused on *conflict of interest* in the peer review system at NIH in 1973. The issue of *age* of principal investigators whose proposals are funded has been raised. Congress has been concerned about the *geographical distribution* of federal research funds and the *secrecy* of the peer review system. Some university scientists have expressed concern about *cronyism* and *elitism*. Other criticisms have come from combinations of the above interest groups. Many studies have been conducted for Congress regarding the peer review systems in NIH and NSF specifically in response to these criticisms.

There are built-in safeguards against some of the problems cited in the preceding paragraph. Conflict of interest, for example, is always possible in a system where scientists are involved in the conduct of research, design of research programs, and evaluation of research proposals. However, it is minimized by regulations that

reviewers shall not evaluate their own proposals or those from colleagues in their own departments or universities. NIH has a system of declaration which is designed to minimize any likelihood of conflict of interest on the part of members of its Study Sections and National Advisory Councils. NSF also has conflict of interest rules.

Chances for cronyism are lessened in peer review systems by the broad range of persons reviewing proposals and by the regular rotation of members from panels. Verbatim reviews sent to principal investigators on their request (or, in some agencies, sent with the approval or declination letter) minimizes the potential for favoritism, while at the same time, anonymity reinforces the potential for candor. Cronyism is minimized also by the provisions mentioned above, that reviewers shall not evaluate their own proposals or those from their departments or universities.

Inequities

Many of the criticisms of peer review are charges of potential or actual inequities. These include cronyism and conflict of interest addressed above, and age discrimination and lack of appeal procedure in case of an adverse decision. Age discrimination, bias, and cronyism are possible as problems, but there has been no documentation to show that there are, in fact, major problems. NSF has instituted a formal appeals procedure in which requests for reconsideration of declined proposals are presented to an Assistant Director (first-level appeal) and then, if necessary, to the Deputy Director (second-level appeal). In 1979, there were 54 first-level requests and 10 second-level requests from a potential pool of 12,476 declinations, though, of course, these figures do not reveal how many investigators resubmitted revised proposals rather than complain about their initial rejection. NIH is considering instituting an informal appeals procedure to supplement its present resubmission policy.

Inadequacies

The inadequacies of the peer review process which have been cited most often by critics are as follows: traditionalism and conservatism of peer reviewers; inability or unwillingness to recognize and recommend support for highly innovative, high-risk proposals; elitism in selection of peer reviewers; lack of elitism in selection of peer reviewers; inadequate review of proposals which are of an interdisciplinary character or which involve large, complex programs; inadequate consideration of past performance of an investigator in evaluation of scientific promise of a proposal; and inadequate protection against possible plagiarism.

With respect to the criticisms of elitism or lack of elitism in selection of peer reviewers, the most emphatic response has been that the essence of a successful peer review process is to have the most competent and talented scientists serve as peer reviewers. This sort of elitism is not only desirable, it is essential to fair and accountable reviews. In order to be more sure, however, that competent and talented scientists are not overlooked as potential reviewers, NIH, as described below, has initiated a widespread search for membership on Study Sections and Advisory Councils.

Commission members met with the senior staff at NIH and NSF about the related criticisms directed to the (1) traditionalism and conservatism or peer reviewers; (2) inability or unwillingness to recognize and recommend support for innovative, high-risk proposals; and (3) inadequate review of proposals which are of an interdisciplinary character or which involve large, complex problems. NIH and NSF claim that there is no validity to criticisms (2) and (3), though they recognize that these criticisms sometimes have to do with award policy and with the first criticism, about traditionalism and conservatism. On that issue, NIH and NSF acknowledge that there is sometimes a tendency for individual peer reviewers to be too conservative. But because of the briefing and emphasis which the staff of both agencies give to peer reviewers to avoid such practices, the problem was considered to be manageable. The three criticisms, then, considered singly and as related, cannot be set aside altogether. They indicate, not perhaps problems to be solved, but dangers to be avoided by encouraging breadth as well as scrutiny in reviews.

With respect to adequate protection against plagiarism, no reliable information is available to indicate whether this represents a real or potential problem. The requirements for adherence to practices designed to avoid conflicts of interest by peer reviewers and the knowledge of the contents of a given proposal by all the members of a panel would make a peer reviewer vulnerable to a serious charge if information in a confidential proposal were plagiarized. It would seem that a greater risk of plagiarism exists when peer review is done by mail.

The listed inadequacies represent opinions for which there is little definitive and documented evidence. The factors which go into making individual decisions about innovativeness, high-risk versus sure bet proposals, significance of past research performance in relation to promise of a research proposal, etc., are so many and varied that one cannot expect peer review or any other kind of review to result in uniform judgments by all reviewers.

Use of Results of Peer Review

Federal agencies which fund research have various objectives, differing from agency to agency and perhaps changing with time. Even though basic, much research serves perceived scientific, technological, medical, and social goals stipulated by Congress or set by the agencies. The Commission believes that these legitimate objectives should be invoked only subsequent to objective appraisals, often by the peer review process, of the scientific merit of proposals.

When factors other than simple ranking of scientific merit are appropriate, their use should be noted with candor within the agency and in dealing with the scientific community. In particular, it is unrealistic to assume or claim that the peer review process has a proven capability for more than assessment of scientific merit. Broad agency objectives need to be met by councils such as those of NIH, by program officers, or by agency officials who can make judgments which transcend the scientific review process. In turn, occasional perceived shortcomings of such overriding judgments should not be attributed simplistically to the peer review process.

There are now more meritorious research proposals submitted than are eventually supported. There is low likelihood of new, major funding in proportion to the number of such quality proposals. Therefore, ratings and rankings developed in review processes should not be used mechanically, or in any other routinely simple way, to make awards. Peer review processes should be continued and refined wherever possible. Agencies should endeavor to develop and make explicit relevant policy considerations that are taken into account in judging between proposals and particularly in deciding which research to support among high ranking proposals.

The days of simple division—what is supported is good science and what is not supported is weak—are gone. As much good science as possible should be supported. Funding policies, based on sound review processes, should be developed through explication of other rationale and consequences. Such openness would help to remove the mystery from the decision-making process while maintaining flexibility and enhancing the credibility of the peer review process.

Related Studies

As was noted earlier, a number of studies dealing with peer review in NIH and NSF have been conducted in the past decade. Some of them were conducted at the request of Congress, and most of them were financed by the agency being studied. "Appendix II: Selected Bibliography" lists many of these studies. The Commission has examined these documents and in some cases discussed the contents with their authors. Further discussions with persons in government and universities were held. Based on these deliberations, the Commission has concluded that the studies correctly determined that the criticisms do not form a pattern and, in most instances, arise out of isolated cases.

Several of the studies made recommendations for improvements in the operation of the peer review systems which have been implemented by the agencies. No such studies have been conducted on internal review processes.

Other Issues

Identification and Selection of Peer Reviewers

Identifying and selecting scientists to serve as members of a peer review panel or to perform mail reviews are the responsibilities of the staff members in each agency. In 1979, following a lengthy and detailed review of its peer review operation, NIH began a new system of nominations for both Study Section and National Advisory Council membership. Requests were printed in the *NIH Guide for Grants and Contracts*. More than 8000 nominations for the expanded Study Sections were received, of which approximately 3500 were considered to have appropriate qualifications and credentials. (The current pool size of established biomedical scientists is estimated to be about 75,000.) Approximately 845 scientists are involved in serving as regular members of Study Sections and about 500 to 600 as *ad hoc* reviewers (who may serve on special Study Sections formed when special reviews are needed or when conflict of interest may arise). Members of Advisory Councils number 162, including scientists and nonscientists. Turnover of membership is 25 percent annually. However, while membership is limited initially to one term of four years, reappointment can be made of previous Study Section or Advisory Council members after a lapse of one year. Prior to 1979, NIH had identified potential Study Section and National Advisory Council members through the advice of professional staff, current and past members, and other informal methods. The decision to broaden the base for nominations was made in response to recommendations of the NIH Grants Peer Review Study Team for a greater number of Study Sections and a larger pool from which to draw their

memberships.[1,2] Primary responsibility for choosing the most competent reviewers still rests with the Executive Secretaries of the Study Sections, who now have a larger identifiable pool from which to draw.

Peer reviewers for proposals to NSF are identified by program officers, division heads, and others at NSF; current and past reviewers; and sometimes even the proposers (principal investigators) suggest appropriate reviewers. Selection for *ad hoc* mail or panel reviewers is made by program directors from computer lists compiled from various resources. There are 87,800 names in the pool. The average number of reviewers for each proposal at NSF is 8.5, usually not more than one of whom might have been suggested by the principal investigator.

When peer review is used at DOD, the reviewers usually are identified and selected by the scientific officers. The Chemistry Division of AFOSR, however, contracts with an external coordinator to identify and select the reviewers. Reviewers for proposals submitted to the Army Research Office are chosen by members of a special committee of the National Research Council.

At times, agencies will provide site visits by teams of reviewers from appropriate disciplines in cases involving either several disciplines or large and complex programs. There is some difficulty in finding peers to evaluate interdisciplinary proposals. Special attempts are made at both NIH and NSF to review such proposals adequately and equitably. NSF is beginning an internal study of its peer review process, including a Foundation definition of "interdisciplinary" and possibilities for saving time in the entire process.

Time and Cost Factors

Time Demands on Reviewers. A widespread complaint of university investigators engaged in laboratory research in the natural sciences is that they do not have enough time to do research. Within the university, considerable amounts of time are spent in classroom and graduate student teaching, departmental and university committee work, fulfilling increasing administrative regulations requiring written documentation relating to employment and termination of employment of research personnel, equipment purchase and maintenance, fiscal management of research funds, etc. To these time demands are added the considerable time needed for writing applications for research funds and progress reports and preparing manuscripts for publications. Success in research productivity results in additional demands such as reviewing manuscripts for professional journals, presentation of lectures at other institutions and scientific meetings, and frequently service in connection with professional scientific organizations. On top of all of these time demands, productive investigators are asked to serve as peer reviewers, as a member of a panel or by mail or both. Surprisingly, a considerable number of university investigators manage to do all of these and do them well.

The time spent by external reviewers evaluating submitted proposals is considerable. Prior to the new system of identification of nominees for membership in NIH Study Sections and National Advisory Councils and the addition of approximately twenty new Study Sections, the Grants Peer Review Study Team had identified heavy workloads as a significant problem for peer reviewers.[1] They had estimated in 1976 that the load was 120 hours of preparation for each reviewer three times a year, plus up to five days for each review session. Because of this, some qualified peer reviewers were beginning to decline invitations to serve on the Study Sections and National Advisory Councils. The increased number of Study Sections and the enlarged pool of nominated peers will help to alleviate this workload problem, but its effect, if any, on the quality of the reviewers is unknown. NSF has minimized this problem, primarily because it uses mail review predominantly in its peer review. While information is not available on the workload of the individual reviewer, an editorial in *Science* estimated that in U.S. science as much as 575 man-years were invested in reviewing research proposals in 1978.[3]

Length of Time Between Submission of Proposal and Final Decision. One of the criticisms of the competitive grant and contract system is that researchers spend a great deal of time writing proposals and then have to wait six to nine months for approval or declination from the agency. These criticisms are directed especially toward agencies in which peer review is used. They are sound in that review processes are indeed extensive, the number of staff and reviewing bodies is limited, the number of applicants is ever increasing, and the provisions that are made for careful and fair review are complex and time consuming. Consequently, there seems to be little that can be done to reduce the current lag between submission and approval or disapproval of proposals.

In the case of NIH, for example, the structured schedule of meetings of the Study Sections and Advisory Councils necessitates deadlines for receipt of applications. The deadlines must be sufficiently far in advance of the scheduled meetings of the Study Sections to permit reading and processing of applications and assignment by NIH staff to an appropriate Study Section. Sufficient intervals of time are needed then for (1) processing of applications (about 8000 to 10,000 for each deadline); (2) distribution to members of Study Sections; and (3) reading and preparation of summary assessments by the Study Section reviewers. Following a meeting of a

Study Section, further time is needed to prepare summary sheets and priority scores in preparation for use by the subsequent meetings of Advisory Councils. Following the meeting of the Advisory Council, the staff is finally in a position to advise the applicants as to the fate of their applications. Inquiry as to whether the overall time involved could be shortened by the addition of more staff at NIH was answered by indicating that very little time could be saved. A similar situation obtains for NSF when panels are involved in review.

With respect to peer review by mail at NSF, the time elapsing between mailing a proposal to a reviewer and the return of the review averages two months. Additional time is required for (1) processing the initial proposal upon receipt; (2) preparation by the program officer of a detailed critique after receipt of all of the reviews from the reviewers; and (3) review by the different levels of NSF staff. If further mail review is required, an additional two months may be added before a final decision can be made.

The long lag time between submission of an application and final decision creates serious difficulties for the investigator in planning for continued support for research personnel and recruitment of new personnel. In the case of a declination, an investigator may have to stop doing research and dismiss research personnel unless local or other funds can be found for interim support.

In the case of agencies using primarily internal review procedures and dealing with much smaller basic research programs, decisions may be reached in a much shorter time. However, it should be recognized that in some of these cases the applicant has had to submit beforehand an informal preliminary proposal which is evaluated as to suitability for consideration by the agency. If the initial proposal is considered to be of interest to the agency, a formal proposal is then requested, and it may be acted upon within a week or two. Information on the average total time involved between submission of an initial, preliminary proposal and final action on the formal proposal with internal review is not available at this time.

Monetary Cost. Monetary cost for peer review at NIH for the year 1979 was about one percent of its external research budget of $1.8 billion for new and competing grant applications. The Chemistry Division of AFOSR contracts with an external scientist to operate its peer review process; the cost is about one percent of that division's research budget. Within the NSF, peer review by mail is less expensive than peer review by panels. NSF spent approximately $18.2 million for peer review in FY 1979, which is about two percent of its total budget for that year. The NIH and NSF figures are not directly comparable, since the NSF figures include staff costs as well as the reimbursement and honorarium costs for panel reviews and the related costs of mail reviews. NIH figures do not include staff costs.

Some agency officials believe, "The true cost of peer review is not in the dollars we spend but in the labor we extract from the scientific community." Investigators believe peer review participation to be an obligation as well as a privilege, so they contribute their time and efforts to the review process. Most peer reviewers receive no compensation for mail reviews and only travel expense reimbursement and a minimal honorarium for panel work.

Summary

The ultimate assessment of quality and merit of research can be made only retrospectively. However, review processes should be examined periodically and account taken of valid criticisms to provide bases for judging the effectiveness and equity of the processes by which proposals are chosen for funding by federal agencies. The Commission states its conclusions and offers its recommendations for improvement of the examination of the review processes in the next sections of this document.

Conclusions

The Commission's deliberations regarding review processes yielded the following conclusions:

1. Scientists, universities, and the government all want a system of review and award which ensures equal opportunity to all investigators, minimizes error, assures fairness, selects the best research, and can be managed with reasonable costs of time and money. A system of review, however, which is totally free of error, differences of judgment, or personal preferences probably cannot be designed.

In submitting a basic research proposal to a federal agency, a scientist is offering his or her best research ideas for consideration. The proposal is the result of much thought and effort. It is, therefore, of the greatest importance to the scientist, particularly in a situation of keen competition for limited funds, that the proposal be considered fairly and critically by the most competent of his or her scientific peers.

It is equally important that the public, represented by Congress and the agencies, be assured that the money invested in research has funded the best research available. Elmer Staats, Comptroller General of the United States, maintains that peer review, where used, is the basis for scientific accountability for research funds.[4]

While it is recognized that there are rational bases for having some of the federal funding agencies use review processes other than peer review, it should be noted that the trend is in the direction of peer review rather than other review processes. Several federal funding agencies have completed studies of their research programs and have concluded that improvements could be achieved by using peer review of proposals. As noted earlier, the Department of Agriculture has been given appropriations by Congress to add a small, competitive grant program that will be reviewed externally and that will emphasize basic science and broaden the base for agricultural research. Other agencies which have initiated external review processes are the Biological Energy Research Program of the Department of Energy and the research programs of the Veterans Administration.

2. The Commission concludes that the plurality and diversity of review processes available are appropriate, provided that equality of opportunity is assured and that the quality of proposals selected is high.

On the whole, the Commission concluded that the systems of proposal review currently being used by the government agencies that sponsor research in universities are appropriate. These review processes for selection of high quality research are not identical, nor should they be. Agencies have chosen the systems that fit their needs according to the character of each agency, its mission, the type of research to be supported, and the oversight functions of Congress.

3. The Commission recognizes the criticisms of peer review and agrees that the peer review system is not immune to faults. Still, the system has worked well, and most agencies have been attentive to developing and testing appropriate safeguards to ensure its integrity and effectiveness.

Fundamental criticisms need special attention, and safeguards against abuses of the peer review system must be expanded. NIH and NSF have examined and continue to study their systems, but not all agencies using peer review have been as attentive. Examples of safeguards already in use include rotation of membership on NIH Study Sections and Advisory Councils, rules regarding conflict of interest in NSF and NIH, and access to peer reviews by investigators through the Sunshine Laws.

Criticisms that are made by investigators who believe their proposals did not receive appropriate review must be handled on an individual basis. The formal appeals procedures of NSF and the informal appeals procedures at NIH are examples of how these systems might work.

Another aspect of the funding process which has been criticized is the use which is made of the results of peer review. Such results are perceived by some as used too mechanically; others hold that funding is not distributed as widely as it can and should be if it is to sustain a large research community. While little evidence has been presented in support of these criticisms, the Commission notes that such perceptions persist and warrant continuing attention.

4. The Commission believes that deciding the direction of U.S. science through the open competition of unsolicited proposals, and especially through the selection of proposals through peer review, is of great importance to the success of U.S. science and, therefor:, deserves support.

Recommendations

1. The Commission recommends that the review systems used in the different funding agencies be examined periodically, both by internal and external groups, to ensure that they are working effectively and equitably.

Review systems are one source of scientific accountability and must be equitable and effective in so functioning. Peer review and internal review systems may develop weaknesses if they themselves are not reviewed carefully.

Extensive and intensive studies of peer review have been undertaken in both NIH and NSF. Similar studies should be conducted of internal review processes.

The Commission recommends not only periodic internal studies of review systems, but also congressionally financed studies. Vigilant surveillance over review systems is needed either by a special charge to the individual congressional oversight committees or by a separate body established for that purpose.

2. The Commission recommends experimentation within the funding agencies to refine the review processes and recommends that legislative or administrative restrictions which limit such experimentation be modified.

The periodic examinations presented in Recommendation 1 will suggest procedural modifications that would improve the review systems. For instance, the Commission believes considerable time and perhaps cost could be saved for all concerned if small, short-term grant applications to NIH could be reviewed by a procedure other than the dual peer review system mandated by the NIH legislation in Public Law 93-352. Certain exceptions are made already, but it may be necessary to amend the law to permit flexibility for the Director of NIH to initiate and implement experiments. Other experiments involving cost and time savings in other agencies should be considered after careful examination of the review systems.

3. The Commission recommends that funding agencies initiate retrospective studies on how effective their review processes have been in assessing the quality and impact of the research they support.

This recommendation stems from studies prepared for the President's Biomedical Research Panel in 1976 as well as from a recent, four-year study of the NSF peer review system supervised by the Committee on Science and Public Policy (COSPUP) of the National Academy of Sciences. Such retrospective studies could suggest improvements in the predictive accuracy of the review of proposals.

Studies should address the following issues:

1. Has the judgment of what is the best science remained the same, or have the criteria changed over time?
2. How does the retrospective assessment of results compare with the prospective assessment of the proposals for research?
3. Have agency program directors maintained high levels of competence in their program fields; to what extent have their priorities been similar to those of active researchers in the field?
4. What has been the justification for apportioning funds, and has this level of funding proved adequate for the research to go forward?
5. Have the programs been responsive to innovative, high-risk proposals, to young investigators, and to interdisciplinary areas?

4. The Commission recommends experimentation by federal agencies in which peer reviewers provide ratings for several aspects of a proposal as well as the overall rating. This would assist program officers in knowing what qualities and in what measure a peer reviewer has assessed the overall proposal and would assist program officers in making the funding decision.

Often peer reviewers disagree with one another about the quality of certain aspects of the same proposal. Categorical ratings as well as overall ratings would allow better comparisons among the reviews of the same proposal and among reviews by the same reviewer. When program officers make the funding decisions, they must sort through the reviews for salient points on which to base their impressions. One of the additional duties of the program officer in some agencies is to choose peer reviewers for proposals, and the information provided in a categorical rating system would help agency personnel to assess the character of the reviews from individual reviewers.

Categories should include the criteria deemed important to the individual agency, such as the following:

1. feasibility of research design;
2. past research performance of the investigator;
3. available resources and facilities;
4. expected contribution of the results to the field; and
5. innovativeness of proposal.

COSPUP has made a similar recommendation regarding the NSF peer review system, and the Commission is in general agreement with that suggestion.

5. The Commission recommends that funding agencies make explicit the nature of the underlying scientific and policy considerations used in arriving at funding decisions.

There is a perception that the clustering of meritorious proposals around a narrow range of priority ratings is being resolved by arbitrary numerical cutoffs. The Commission recognizes that factors in addition to the peer review rating must be taken into account in reaching a funding decision by a given agency. Such factors would include relevancy to the mission of the agency, impact on a newly emerging area of research, unique circumstances to pursue an area of research, as well as scientific, technological, medical, and social goals stipulated by Congress or set by the agencies. While a legitimate and rational remedy for the difficulties caused by limited funding and the large number of meritorious applications would be an increase in funds to support more of the meritorious proposals, it must be recognized by the scientists, on the one hand, that considerations in addition to pure scientific merit are proper and necessary in resolution of this situation. On the other hand, the funding agencies must recognize that the use of factors in addition to priority ratings must be based on sound scientific and policy considerations.

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Appendix III: Sources

The Commission is indebted to the many persons who have provided information and advice, and it wishes to acknowledge its appreciation for their efforts. Invited expert witnesses have testified on the issues within the Commission's purview at its monthly meetings; open hearings have been held on five university campuses; subcommittees have met with individuals and groups from the Federal government; and members and staff have attended or made presentations at meetings and hearings convened by educational associations, government agencies, and Congress.

Witnesses. The following individuals presented views and gave assistance in the development of this document. The Commission wishes to emphasize that the views in this document are its own and not necessarily those of the listed individuals. This list includes meetings through March 1980.

Robert Akers, National Institutes of Health
Richard Atkinson, Director, National Science Foundation
Donald L. Ball, Air Force Office of Scientific Research
James M. Banner, Jr., American Association for the Advancement of the Humanities
Robert Barlow, Cornell University
Robert M. Bock, University of Wisconsin, Madison
Charles Boghosian, Army Research Office
Howard W. Bremer, University of Wisconsin, Madison
Newton Cattell, Association of American Universities
Mary Chezmar, National Science Foundation
Stephen Cole, State University of New York, Stony Brook
Theodore Cooper, Cornell University
Robert Cutler, National Science Foundation
John M. Deutch, Former Under Secretary, Department of Energy
Sidney Drell, Stanford Linear Accelerator Center
Anthony Egginton, British Science Research Council
Gary Evans, Department of Agriculture
Osmund Fundingsland, General Accounting Office
George Gamota, Department of Defense
Howard Gobstein, General Accounting Office
Delphis C. Goldberg, U.S. House of Representatives Subcommittee on Intergovernmental Relations and Human Resources
Michele Harvey, Alcohol, Drug Abuse, and Mental Health Administration
Bryant Kearl, University of Wisconsin, Madison
Thomas J. Kennedy, Jr., Association of American Medical Colleges
Philip Kropatkin, Deputy Director, Audit Agency, Department of Health, Education, and Welfare
Thomas Morgan, Association of American Medical Colleges
Morton Myers, General Accounting Office
Gilbert S. Omenn, Office of Science and Technology Policy
Michael Pelczar, Council of Graduate Schools of the U.S.
Robert Rabson, Department of Energy
William F. Raub, National Institutes of Health
Jerold Roschwalb, National Association of State Universities and Land-Grant Colleges
Robert Ryan, Office of Naval Research
Jack Sanderson, National Science Foundation
Reilly Schaefer, University of Wyoming
Steven Schiaffino, National Institutes of Health
Helen Schroeder, National Institutes of Health
I. M. Singer, Committee on Science and Public Policy, National Academy of Sciences
Elmer B. Staats, Comptroller General of the United States
Richard E. Stephens, Department of Energy
Edwin Young, University of Wisconsin

Agency Liaison. These persons have been appointed by their agencies:

Salvatore Cianci, Alcohol, Drug Abuse, and Mental Health Administration
George P. Millburn, Department of Defense
Richard E. Stephens, Department of Energy
Osmund Fundingsland, General Accounting Office
Walton Francis, Department of Health, Education, and Welfare
James R. Lawson, National Aeronautics and Space Administration
William F. Raub, National Institutes of Health
Jack Sanderson, National Science Foundation
Eliot R. Cutler, Office of Management and Budget
Philip M. Smith, Office of Science and Technology Policy

Open Hearings. Over seventy persons testified before the Commission during hearings at the national conference of the American Association for the Advancement of Science and on the campuses of the University of Alabama, Birmingham; California Institute of Technology; Stanford University; the University of Wisconsin, Madison; and the University of Utah with the Inter-Mountain University Research Association. A number of these speakers presented views on review processes in addition to other topics under consideration by the Commission.